CURRENT EXPERIENCES IN THE APPLICATION OF THE INTERNET OF THINGS IN THE FOOD INDUSTRY, REVIEW

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Review paper

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Abstract: Modern agriculture and the food industry have a chance to apply modern technologies related to Industry 4.0. In this context, the review discusses the benefits that the food industry can have from incorporating Internet of Things (IoT) into its production processes and control system. The application of IoT will enable companies to more easily and efficiently achieve the set goals of the organization, produce high-quality and safe food and demand and expectations of consumers. This paper presents the latest knowledge about the potential application of IoT and its importance in the food production and processing sector, primarily in the food industry. In addition, the paper describes some barriers that obstruct the application of IoT in the food processing sector. Finally, the future trends of IoT research and application in this sector are listed. The Internet of Things has the potential to contribute to the improvement of the food industry and the food sector as a whole. This potential refers to: the overall practice of sustainability of the sector, improvement of working conditions, reduction of production costs, more efficient use of raw materials, reduction of energy consumption, reduction of the amount of waste and creation of environmentally friendly products.

Keywords: barriers and challenges, food processing, food and agribusiness sector, internet of things (IoT)

INTRODUCTION

The Internet of Things (IoT) are modern technologies in the field of information technology (IT). The application of IoT has revolutionized industry, society and everyday life [1]. IoT represent systems that can connect and communicate with other devices via the Internet. According to Dadhaneeya et al. [2], IoT is a system that enables connecting devices with anyone, anywhere and anytime. Mishra et al. [3] define IoT "as a global infrastructure for the information society, which enables advanced services by connecting (physical and virtual) things based on existing and developing interoperable information and communication technologies".

The Internet of Things (IoT) is a production concept within Industry 4.0. IoT encompasses a number of core technologies and services, which are part of a wider technological ecosystem of connected technologies (for example, artificial intelligence, cloud computing, next-generation cyber security, advanced analytics, big data, various connectivity/communication technologies, blockchain, etc.). The Internet of Things consists of an information technology infrastructure for the collection and distribution of data. The basic components of IoT technologies are endpoints and devices (sensors and actuators), IoT gateways (and device management) and IoT platforms. There are many parts in every IoT device: sensors, actuators, boards, antennas, chips, micro-electromechanical systems and more. Physical devices are interconnected with the Internet and other networks through recognizable IP addresses. IoT collects data from various applications and sends them to the network and application components for further processing and integration of the obtained information [4]. IoT enables the detection of objects (things) and their remote control through the existing network. In this way, IoT enables the collection and exchange of data between objects. Collected data is exchanged via wireless connection technologies. IoT-WSNs facilitate the provision of data to other layers of the IoT architecture.

The Internet of Things are devices that enable the fusing of information technologies (IT) and operational technologies (OT) as elements of the overall transformation of the industry within the framework of Industry 4.0. This can significantly affect the efficiency and performance of production systems. IoT devices can communicate with each other, collect and share data in real time [5], without the need for human intervention. IoT is a logical stage in the development of the Internet and represents the continuation of M2M (machine-to-machine) networks and technologies, mobile technologies, RFID (Radio-frequency identification) and a number of other devices and technologies.

The beginnings of IoT are related to the development and application of RFID, where in the 1990s RFID was only used to track items in various operations (for example, supply chain management and logistics). RFID technologies, sensors and several wireless innovations have influenced the development of multiple applications in connecting devices and "things" [6].

The food industry is a field of human activity in which agricultural products are processed into food products with an extended shelf life using various technical procedures. Modern agriculture and food processing, often included under the name food sector or agro-food sector, should apply modern technologies related to Industry 4.0. Within this, the food industry should use the technologies covered by the IoT.

IoT technologies are very present in agricultural production. They are applied in many places and ways (monitoring of soil moisture content, efficient irrigation systems, optimization of fertilizers, control of crop pests and diseases, optimization of energy use, and others). Recently, several platforms have been developed and put into practice that enable agricultural producers to better organize their business and monitor agricultural products in the food supply chain. However, the application of IoT in the food industry is just beginning. Although there are numerous opportunities, the mass application of IoT is prevented by barriers within the industry itself. This research is a continuation of earlier research in this area [6], and represents a comprehensive examination of the existing scientific literature regarding the application of IoT in the food industry. Clear recommendations are given here for the development of practical applications in the future, emphasizing the need to integrate advanced technologies in order to develop a smart food industry.

Application of IoT in the food sector

Regardless of the rapid progress and changes so far, the food industry faces a number of problems. This requires rapid reform and certain improvements that will increase efficiency and meet the requirements related to process modernization. IoT can help solve problems that are logged and create an environment to solve other problems as well. The opportunities for applying IoT in the food sector are constantly expanding. IoT encourages the management of companies from the food industry to create a new strategy that enables their access to Industry 4.0. A large number of IoT applications intended for the food industry have been developed. There are numerous examples of the use of these applications in companies in developed countries. IoT can strengthen and improve the food sector through various solutions, including real-time data analysis and simulation, remote monitoring and preventive analysis. Through IoT, users can give commands to robots that perform various manufacturing activities. IoT provides an advanced environment for food processing in the future.

Food safety and quality management, improvement of the efficiency of the production process, modernization of food packaging systems, and food supply chain management and food storage management are sectors of the food industry that require changes and in which the application of IoT can help management find better solutions and simplify the company's operations [7], [8]. According to Kodan et al. [9], IoT provides an advanced environment in all stages of production of the food sector (farms, food industries, warehouses, supply chains, prevention of food wastage and waste management, management of energy and other resources, etc.). In practice, IoT is used as sensor devices for data collection (for example, sensors for measuring temperature, relative humidity, light intensity, location, etc.) and as part of communication systems (Bluetooth, RFID, 4G, etc.). Radio Frequency Identification (RFID), Wireless Sensor Network (WSN) and M2M (machine to machine) are most often used to collect data in IoT blocks [10]. This enables easier data transfer to resources for data

processing and storage (human resources, computers, etc.).

The IoT ecosystem collects, analyzes/processes and transmits data. IoT systems are divided into: data generation layer, data transmission layer, data processing layer and application layer [2], [11]. The data generation layer is important in the IoT system in the food industry. Cameras, 2-D barcodes, handheld devices, RFID tags, probes and other types of sensors are used as sensors [12]. The food industry uses mechanical, optical, electric magnetic, biological, chemical, acoustic, thermal and other sensors. Temperature sensor, humidity sensor and chemical sensors are most often used in the food processing sector. Sensors are installed on many machines (for example, heat exchangers, evaporators, drying chambers, vacuum ovens, lyophilization chambers, incubators, etc.). Through the transmission layer, a connection is established between the generation layer and the data processing layer [12]. In this way, different devices and components within the IoT ecosystem are connected and communication between them is achieved. Wi-Fi, ZigBee, Ethernet, LoRa, GSM, RFID and Bluetooth are the most widely used communication technologies. This phase is extremely sensitive to cyber attacks, which is why it is necessary that the data being transmitted is protected. The data processing layer is essential in dealing with the huge amount of data produced by sensors [13] . This layer collects data from the transport layer, decodes it, and stores it in the cloud, making the data available to authorized persons [14], [15]. Several cloud platforms are used in IoT systems. The fourth layer in the IoT architecture is known as the application layer. This layer provides concrete real services to the user (for example, human-machine interaction takes place here in this layer). Data can only be given to authorized users and must be protected from threats. This is achieved through authentication techniques: keys, passwords, Bio matric security OTP and other secret access codes [13].

Radio Frequency Identification (RFID)

RFID uses radio waves to transmit small amounts of data. RFID technology enables the design of chips for wireless data transmission. There are several categories of RFID technologies, each with its own advantages and disadvantages. The requirements of the application determine which RFID technology is appropriate for a particular case.

The use of RFID in the food industry has grown in recent years. A system based on RFID was used to collect information for the purpose of ensuring food safety [16], and to monitor and control various activities in the supply chain. RFID technologies are often used in traceability systems and food safety assurance in the food supply chain. RFID sensors are applicable in various applications for food quality evaluation [17], [18]. Several authors have proposed the simultaneous use of RFID and other technologies. Gaukler et al. [19] investigated the use of RFID technologies and sensor technologies to determine the expiration date of perishable food products. Zhang et al. [20] have developed an algorithm to monitor food contamination and return in case the existence of a cause for the occurrence of unsafe food is determined. Alfian et al. [17] developed a traceability system that uses RFID and Internet of Things sensors, where they used RFID technology to search and track perishable food, while they used IoT sensors to measure temperature and humidity during food storage and transportation. The use of RFID technologies, mobile user interfaces, machines with internet connection and ICT for identification of production status enables easier and more efficient production and implementation of automatic control in processes in agricultural production. This is very important for the efficiency of the application of management systems (MS).

Wireless technologies (WSN) for data collection, transmission and storage

The transfer of data from the sensor elements of information and communication technologies (ICT) to the place of data storage in the food industry takes place through advanced communication technologies (for example, LAN, WAN, ZigBee, Wifi, Bluetooth). WSN is used for a variety of applications, including information gathering, machine monitoring and maintenance, environmental monitoring, real-time automated monitoring of raw materials, semi-finished products, and finished products, and for ensuring food safety [21]. A wireless sensor network usually consists of radio frequency systems for transmission and reception, electronic based sensors, microprocessors and power sources. A WSN is a wireless sensor network and is a cooperative network organiza-

tion in which a set of nodes can communicate wirelessly. Because they use inexpensive batteries that can last for years, low-power broadband networks (WANs) are being incorporated into IoT networks in industrial systems and commercial facilities. WANs are suitable for these applications, as they do not require high bandwidth and real-time results. ZigBee is a wireless standard of low power and data transmission speed that is higher than the speed achieved with LPWAN. ZigBee is used in short-range networks (less than 100 m). Bluetooth is a short-range communication network. It is widely used in smart portable medical devices (for example, oximeters), smart watches, personal devices (for example, phones), and smart home applications (for example, smart locks), etc. Wi-Fi is an IoT technology that is most often used in networks with devices permanently connected to the electrical grid. Wi-Fi technology supports high-speed data transfer (up to 9 Gbps). Wi-Fi infrastructure is represented in digital mobile services [9].

IoT-based applications

Bouzembrak et al. [22] analyzed in detail the application of IoT in the food sector. Li et al. [23] developed an application applicable to a traceability system for prepackaged perishable food, using integrated IoT technologies. Several authors have proposed solutions for information system architecture that uses IoT technology [24], [25]. IoT-based monitoring and control applications in the food supply chain have been developed. Maksimović et al. [26] proposed a system based on IoT, which is intended for tracking and tracking food packaging and transportation. The possibilities of using IoT for monitoring food safety and quality by determining dangerous ingredients in food [27], monitoring the freshness and shelf life of food along the cold supply chain using sensors for measuring temperature, relative humidity and pressure in products and RFID data transmission systems are being explored [28], gathering information from food packaging systems [26] etc.

Integrating IoT with other ICT technologies

The scientific literature describes several applications intended for use in the supply chain, in which IoT is used together with other technologies (for example, blockchain, big data, CC, CPS, etc.). Mededjel et al. [29] described an integrated approach that uses IoT and the cloud for the traceability system. Alfian et al. [30] presented a real-time monitoring system that uses IoT devices on a big data platform. In addition, several traceability systems for ensuring food safety are described, which are based on IoT and blockchain technology.

Blockchain

Blockchain is a cryptographically secured distributed ledger technology used to record the history of transactions. Each node on the blockchain system keeps a copy of all previous transactions/records that are transferred on that system. Blockchain provides auditability, immutability, smart contract, traceability and a trust worthy system [10]. Blackchain has so far been applied in systems for traceability, certification, management of information systems etc. [31], [32].

Big-Data

In the food supply chain, there are a large number of points at which data is generated, for which it is necessary to have an appropriate monitoring system. Such large data can hardly be processed by a computer using simple mathematical analysis. Big data is defined as a set of huge amounts of data that cannot be collected, saved and processed in real time with modern data analysis technologies [21]. Big data analysis, artificial intelligence, machine learning and others are used to process the collected data in practice. Big data is characterized by speed, veracity, volume, value and variety. This technology has enormous significance, because most of today's activities (for example, business, production, services and agriculture, etc.) are focused on the collection and processing of data.

Cloud computing (CC)

The National Institute of Standards and Technology has defined cloud computing as "a model that provides network access to a shared set of configurable computing resources (for example, networks, servers, storage, applications, and services) that can be quickly provisioned and released with minimal effort" or service provider interaction" [10]. Cloud computing provides a simple computing infrastructure for processing big data [21]. At client's request, Cloud Computing provides computing services (for example, storage, servers, networking, analytics, intel-

ligence and software) over the Internet ("the Cloud"). Companies whose work generates a large amount of information use cloud computing. They use computer and network resources to store information. The main advantage of a cloud-based strategy is the ability to accumulate data from different locations and devices. Embedded hardware collects information coming from IoT equipment on site. Relevant information is transferred to the cloud level. In such frameworks, the definition of tasks plays a key role, and the optimized scheduling of requests affects the improvement of system performance and productivity [33].

In the food industry and primary food production, modern video surveillance systems (high-resolution, HD cameras) are often used for defect identification and inspection. In this way, a huge amount of data is created, which often needs to be processed and refined. IoT helps to separate important from irrelevant data. This enables the elimination of erroneous data obtained by manual measurement and the direct extraction of data from electronic sources, their safe transfer to the electronic system for keeping documentation [21]. Specific image processing software is used to process the data, which contains photos taken using cameras or optical sensor elements.

Artificial intelligence (AI)

A large amount of research is devoted to explaining the significance of the application of artificial intelligence (AI) in the automation of certain operations and procedures in agricultural production [34] and in the food supply chain [35]. Artificial intelligence and machine learning systems enable the collection and processing of large data important in food production and processing. The introduction of machines guided by artificial intelligence in agriculture and the food industry has resulted in a change in the way crops are grown, produced and processed. Automated mechanical robots are used in various processing operations (for example, sowing, irrigation and harvesting, and industrial processing and packaging of food products).

With recent technological advances and the increasing power of machine computing, artificial intelligence-driven technologies are increasingly being used to identify and solve specific types of business problems. This is very important for companies in the food production sector, where the impact of AI-driven technologies and systems creates new opportunities and challenges [36]. In support of various applications in the food production sector, artificial intelligence techniques have their contribution in the identification of knowledge models, service creation and decision-making processes [37]. AI offers general algorithms for prediction [38], accuracy and performance evaluation, as well as pattern classification that can help solve problems in the field of agriculture, such as pest identification and selection of treatment methods [39]. The integration of the most modern AI technologies with WSN represents the way to transform the food sector. It represents an opportunity to optimize production practices, improve the use of resources and significantly increase the volume of production.

Food sector and Industry 4.0 technologies

Industry 4.0 (I4.0) includes various forms of technological development and dynamization of the economy through the change of production lines, which increases the flexibility of production [21]. Industry 4.0 implies the application and integration of the latest developments based on digital technologies and the process of interoperability between them [39]. The fourth industrial revolution has already begun in the food industry [2]. Industry 4.0 technologies have the potential to provide better digital solutions to solve everyday problems. The adoption of various advanced technologies (for example, IoT, AI, big data, robotics, 3D printing, sensors and actuators, simulation and RFID) in the food sector is contributing to the change of food industries into Food Industry 4.0. The fourth industrial revolution in the food sector has been described quite effectively by Hassoun, Bekhit, et al. [40]. Many countries have started to implement certain elements of I4.0 in different stages of agricultural food production [41]. In practical application are smart machines, which, thanks to artificial intelligence and machine learning, perform many tasks (for example, sorting, packaging and quality control). Industry 4.0 technologies (digitalization, data analytics, robotization and automation) will facilitate the implementation of the most complex operations in food production and processing in the coming years [42].

The current situation in the application of IoT in the food sector

Theoretical and practical research on the internet of things (IoT) has been in great expansion in recent years. Several review papers have been published on the topic of IoT application in the food sector. In the work of Bouzembrak et al. [22] current knowledge on the application of IoT in the food sector is given. In addition, researchers have analyzed the use of ICT that can be integrated with IoT: working with big data [43], working with blockchain [44], etc. Rejeb et al. [45] list examples of scientific publications that systematize previously published research related to IoT and agriculture: the role of IoT in the food supply chain and food safety, food quality management, protected agriculture, IoT applications in agriculture, and others. Ben-Daya et al. [46] studied the potential, challenges and role of IoT and related technologies (for example, blockchain) for quality management of food supply chain during the analysis of published papers.

Dadhaneeya et al. [2] believe that IoT has a multiple role in the food industry. These authors state that IoT in the food sector enables two-way communication between food producers and consumers, product monitoring in a certain time and remote monitoring (this ensures that the user does not have to be physically present near certain processing plants or equipment for observation), process control in certain stages of food processing (for example, pasteurization, sterilization, cooling, freezing, packaging, etc.), increasing the safety of employees, goods and equipment from physical threats and reducing losses and damage, better functioning during the execution of certain activities, collection and storage of useful data (for example, data to assess food safety and quality), adapting processes and products according to individual consumer preferences and making the best decisions (for example, finding solutions to problems using artificial intelligence and making appropriate decisions). IoT finds application in all phases of the food sector. In this chapter, a brief overview of the forms of application in the key phases of the food sector will be given: agriculture, food processing, process and product quality analysis, product packaging, food supply chain management, data collection in data banks.

Application of IoT in agriculture

The Internet of Things (IoT) has led to a drastic change in the functioning of the agricultural sector and to the introduction of the term "smart agriculture". This term refers to the application of work procedures based on state-of-the-art technologies and data to improve agricultural operations and increase production per unit of work. Various sensors, actuators, big data analytics, cloud computing and, in recent years, artificial intelligence are in use in primary agricultural production. In addition, smart vehicles, drones and various machines that function with the help of IoT are in use. The application of IoT in agriculture enables the collection of a large number of very heterogeneous data (for example, measurement of meteorological data, land quality parameters, etc. [47]. Based on this data, irrigation systems can be optimized, the progress of crops, livestock movements, and human activities can be monitored. This data can be transmitted using wireless sensor networks, and stored and analyzed using cloud computing and other sophisticated analytical methods. IoT enables access to the system from remote locations via tablets or smartphones.

The advantage of the application of IoT and related technologies in agriculture, among other things, is reflected in the improvement of yields, reduction of costs, reduction of the impact of production on the environment, more efficient use of resources and better organization of work [11], identification and monitoring of products in the food traceability system [48], more efficient use of resources, increasing the efficiency and transparency of the supply chain, optimizing production, reducing costs and ensuring food safety and quality [45].

As challenges related to the application of IoT in agriculture in the coming years, Morchid et al. [11] states: ensuring superior efficiency; cost reduction while developing a cost-effective strategy for IoT application, developing a system that will use heterogeneous devices, and the ability to adapt devices to other devices in the environment, and improving the production and reliability of software and the development of portable devices.

The role of IoT in the food industry

IoTs are used in food processing processes in different ways [2]. The following possibilities are par-

ticularly emphasized in the literature: monitoring and control of processing equipment and predictive maintenance, process control, inventory management, process traceability monitoring, energy management, etc. IoT enables real-time monitoring of modern processing equipment (for example, furnaces, mixers, dryers and conveyors). In addition, IoT enables the adjustment of the parameters of the production system based on remote control, the timely prevention of errors that can lead to equipment damage or endangering the safety of the food product, and the prevention of downtime and the reduction of maintenance costs. IoTs are used to monitor and control numerous factors in the food industry, which affect product safety and quality [8]. IoT sensors in real time can provide information about product stocks, thereby influencing unnecessary accumulation of products or timely supply of the market with the necessary quantities of products. Through traceability, IoTs enable the visibility of flows in real time. This enables timely making of the best decisions in the entire supply chain. Finally, IoT devices provide automation of machines and equipment in industry (for example, using electricity for lighting or heating).

IoT in food supply chain management

Supply chain management is very complex and dynamic. Demands on the companies that make up the chain are increasing. A large number of researchers deal with this problem in order to help companies to fulfill numerous requirements faster, simpler and more efficiently. In the food supply chain, IoTs enable asset tracking, increasing supply chain visibility and predicting demand for specific food products. They influence the optimization of transport routes and better organization of logistics [49], [50].

Shoomal et al. [51] explored the current challenges and future directions of IoT deployment in supply chains, focusing on drivers and barriers to IoT deployment. They identified issues of security, privacy, interoperability, standardization and energy efficiency as barriers to effective IoT application in the supply chain. Khan et al. [52] investigated the barriers obstructing the application of IoT in the food supply chain. According to their findings, there are numerous batteries from which the authors single out: complex food supply system, legal and regulatory standards, data heterogeneity, lack of qualified personnel, absence of knowledge management system, lack of trust, poor IT infrastructure, low awareness of the benefits of IoT, accessibility of IoT , the high investment and maintenance costs of IoT systems and the absence of IoT vendors, especially in developing countries.

Núnez-Merino et al. [53] provided a detailed analysis of research on the application of Industry 4.0 in the manufacturing industry, with a focus on the supply chain. Integration of multiple technologies from Industry 4.0, according to Yadav et al. [10] provides low-cost solutions and enables the strengthening of the food supply chain. IoT devices and sensors are used to record information in traceability systems, after which the data is entered into the blockchain network. Data on the blockchain network is secure, time-stamped and cannot be used by a third party. It is not possible to manipulate and change data for the purpose of any kind of fraud. Blockchain technology has potential for application in traceability and food safety systems [54], [55]. A number of papers deal with traceability systems based on RFID and IoT [17], [56], [57]. In several papers [58], [59], the authors described the possibility of joint use of Blackchain and IoT.

Data banks

A lot of data collected by IoT is fed into databases. This enables improvement of food safety, insight into customer behavior and needs, identification of areas for improvement of production practices and adaptation of producers to meet consumer needs [49], [60].

FUTURE RESEARCH DIRECTIONS FOR IOT APPLICATIONS

In the near future, it will be necessary to invest significant efforts for a more efficient incorporation of IoT into existing ICT systems and the creation of a unified information infrastructure [7]. In this context, the attention of researchers should be directed in two directions: development of IoT architecture and adaptation to new fields of application. There are a few issues that come with the first segment. Network layer limitations include Internet connectivity, standardized interception, interference, transmission loss, transmission range, network management, communication protocols, and latency. Increasing the

security and privacy of IoT systems will enable a better understanding and expansion of the area of their use in the food sector.

After the adoption of new food safety standards, there were new requirements for the development of IoT systems [61]. These systems should enable timely prediction and prevention of undesirable effects on contamination and product safety [62], [63]. In some extreme cases (for example, processing procedures or devices that function at high temperatures) the development of sensors is difficult. Sensors for these environmental conditions are sensitive and very expensive, which can prevent their wide application. In addition to high costs, an obstacle to the application of IoT in the food industry can be the lack of specialized experts for the maintenance of IoT systems [64]. Finally, it is necessary to emphasize the need to develop IoT technologies adapted to work in a wide range of production conditions and a large assortment of different products.

Future research should cover topics such as WSN, sensors, cloud computing, machine learning, AI, blockchain, UAVs and deep learning. Rejeb et al. [45] recommend that future research focus on artificial intelligence techniques, big data and blockchain. This leads to the strengthening of smart and precise food production and processing.

Among the topics for future research in the food sector, there are (1) topics related to the application of IoT for the development and functioning of technological infrastructure, namely: (a) interaction between IoT and Industry 4.0 technologies; (b) barriers that hinder the simultaneous application of IoT and Industry 4.0 in operations; (c) the impact of IoT on the performance of different technologies in the food industry and (2) IoT for establishing business relationships: (a) the potential of IoT to drive initiatives for eco-labeling and supplier certification in order to establish sustainable agri-food supply chains; (b) research on the impact of IoT on cooperation in the supply chain in the agri-food sector; (c) identifying how IoT can be applied to solve problems in target markets, improve customer satisfaction and provide sustainability information to stakeholders in the agri-food sector [39], [65], [66], [67], [68].

When it comes to trending topics in areas that combine IoT and the food sector, research on RFID, GPS, remote monitoring, Zigbee and SDN are of great importance [45]. In addition, it should be emphasized that new technologies (for example, cloud computing, AI, machine learning, big data and blockchain) have become essential in the process of digitization in agriculture and the development of smart agriculture [69]. Rajeb et al. [45] emphasize the need for additional research on the consequences of the use of IoT on the organization of practices in the food sector and policies in order to realize sustainable food supply chains.

In the near future, research should be directed towards the development of Internet of Nano Things (IoNT) and green Internet of Things (Green Internet of Things, Green IoT) [70].

Conclusion

This overview paper deals with the current state of application of IoT technologies in the food sector, primarily the food industry. Based on the analyzed literature, trends were determined and the potential of IoT to contribute to the faster development of the food sector at the beginning of its inclusion in Industry 4.0 was explored. The Internet of Things (IoT) provides significant opportunities for improving production procedures, improving sustainable work methods in all stages of production, improving food safety, improving traceability of products in the food supply chain, and more. The application of IoT as part of Industry 4.0 offers a quick response to customer requests, and contributes to improving productivity and making decisions in real time. However, there are still some problems in the development and functioning of IoT, which need to be solved before the direct application of IoT technologies in the food sector, including the food industry.

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